RANSCO
A Subsidiary of DESPATCH INDUSTRIES, INC.

RANSCO 900 SERIES
BENCH CHAMBER
INSTRUCTION MANUAL

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RANSCO
BENCH CHAMBER

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-- N O T I C E --

This unit is equipped with the new 20 amp rated T-slot plug designed to be plugged with a Hubbell Model 5362, or equal, connecting receptacle. This new plug/receptacle will provide increased safety for this chamber installation. If you require further information, contact:

RANSCO INDUSTRIES, INC.
(805)487-7777

I

GENERAL DESCRIPTION

The Ransco Industries Temperature Test Chamber permits component testing under either hot or cold temperature environments. A closed air flow system transfers heat to or from objects under test. The chamber is heated by a low-inertia coil heater and cooled by the injection and evaporation of a liquified gas. An advanced (Ransco RDC) control system holds chamber temperature to close tolerance.

A substantial variety of accessories and optional equipment are available for the test chambers; only the most frequently used models are described in this manual. Typical examples are control panels, test trays, test fixtures, cycle-time controllers, rate-time programmers, and computer/buss interfaces.

Specification for test chamber models are given in data sheets at the rear of this manual.

Figure 1

II

CONTROL OPTIONS

TEMPERATURE CONTROL

This chamber may be equipped with a Honeywell Dialapak, 3 mode, time proportioning control, or a Ransco "C" circuit in lieu of the "RDC" controller. The Ransco RDC features a digital temperature set point switch and temperature display which is calibrated in degrees C or F. Refer to the enclosed electrical schematic and the instrument instruction manual.

HIGH AND LOW LIMIT CONTROLLER

This chamber may be equipped with a Honeywell Dialapak high and/or low limit controller. These instruments have an analog temperature set point dial calibrated either in °C or °F. Anytime the chamber temperature exceeds the limit set point, the control will trip, and conditioning will stop. Power will not be restored until the chamber temperature is within tolerance. Refer to the enclosed electrical schematic and the instrument instruction manual.

III

OPERATION

The test chamber temperature is set and maintained by the control panel and control circuitry. This combination results in a constant, controlled, manually-selected chamber temperature. A Ransco DRP-13 Digital Rate Programmer can be added as an option to obtain a series of preset temperatures and time durations. Also available are computer interface buss accessories which allow the chamber to be controlled from a host computer.

In the event of a controller malfunction, the chamber and test object are protected by two overtemperature safety thermostat from excessive temperatures. Access to the object under test is provided by a test tray or fixture.

One of the overtemperature thermostats is adjustable and is located on the front panel of the chamber. The other overtemperature thermostat is factory calibrated and is mounted behind the chamber rear panel.

HEATING ONLY OPERATION

If the test chamber is to be heated only above chamber ambient, cooling gas supplies and plumbing are not needed. Operation of the chamber then requires setting the temperature control and overtemperature safety set-points. If the DRP-13 is to be used, refer to the controller instructions section included with these options.

1. Attach the test fixture or tray to the chamber.

2. Insure that the POWER switch is off.

3. Plug the chamber power cord to the correct line power. Avoid adapters that will either unground the chamber or will permit connection to the wrong power source. Check the current rating of the circuit.

4. Set the TEMPERATURE SET-POINT control to the desired temperature.

5. Set the OVERTEMPERATURE SAFETY SET-POINT control to a temperature that is higher than the desired chamber temperature but lower than a temperature at which the test object might be damaged.

6. Turn the POWER switch ON and allow the chamber to heat to the correct operating temperature.

Should a controller malfunction occur and the test chamber reach the adjustable overtemperature set point, the overtemperature thermostat will automatically cut off the line power to the heaters.

If the factory calibrated preset temperature is exceeded, then power to the chamber is interrupted. To restore power, the power on/off switch must be cycled on/off/on.

INSTALLATION OF COOLING GAS

If the test chamber is to be cooled below chamber ambient temperature, it is necessary to provide a source of liquified coolant gas. The type, quality, and handling of the gas is quite important as is the plumbing used to deliver the gas to the test chamber. Most test chamber operational problems are caused by improper gas use; thus, the installation procedures and precautions should be reviewed carefully before operating the chamber.

The liquid coolant gases should be used only after observing stringent safety considerations and practices.

```
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                WARNING                                  *
*                                                                         *
* Nitrogen and carbon dioxide gases can cause asphyxiation and death      *
* if used in confined, poor-ventilated areas.                             *
*                                                                         *
* Nitrogen and carbon dioxide as liquid or cold gases can cause           *
* freeze burns of the eyes and skin.  Do not touch frosted pipes or       *
* valves.                                                                 *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

Nitrogen is a non-toxic gas, but it can cause asphyxiation in a confined area that does not have adequate ventilation. Any atmosphere which does not contain enough oxygen for breathing (at least 18 percent) can cause dizziness, unconsciousness, or even death. Carbon dioxide affects the important acid-base balance within the body; the body can tolerate increased amounts of carbon dioxide only in limited concentration. This is recognized in OSHA standards where a Threshold Limit Value of 5,000 parts per million by volume (0.5 percent concentration) has been adopted. For safety, concentrations above this level should not be permitted; increased concentrations can cause bodily harm or death.

Nitrogen and carbon dioxide cannot be detected by the human senses and will be inhaled like air. If adequate ventilation is not provided, these gases may displace normal air without warning that a life-depriving atmosphere is developing. Store containers outdoors or in other well-ventilated areas. Never enter any confined area where these gases may be present until the area is purged with air and is checked for a breathable atmosphere.

Never use containers, equipment, or replacement parts other than those specifically designated for use in nitrogen or carbon dioxide service. Gaseous nitrogen or carbon dioxide should be released only in an outdoor open area if disposal is required. Liquid nitrogen or carbon dioxide should be dumped into an outdoor pit filled with clean, grease-free and oil-free gravel, where they will evaporate rapidly and safely.

USE OF LIQUID CARBON DIOXIDE (CO_2)

Before purchasing or installing CO_2 gas supplies, insure that the test chamber is the correct model to use CO_2 (High 6205 KPA or 900 PSI or Low 2069 KPA or 300 PSI) and that the desired low temperature can be reached by use of this gas. The following special CO_2 requirements must be met:

1. The liquid CO_2 should be furnished by a reputable source, preferably one which furnishes coolant to laboratories, hospitals, etc.

2. The liquid CO_2 cylinder must be a siphon-type.

3. The interior of the cylinder must be clean and absolutely dry before being filled by the supplier.

4. Use of "welding grade" CO_2 offers no assurance of proper trouble-free operation as the internal condition of the cylinder and its previous use are more important than the quality of the CO_2 in this case.

5. Never fully exhaust the cylinder after use or leave a cylinder which is to be returned to the supplier with the valve open. This will permit moisture or other contaminates to enter the cylinder and cause serious problems when the cylinder is reused later. If a cylinder is returned to the supplier without a positive pressure, it must be purged with dry nitrogen by the supplier before filling.

Other important factors in the use of CO_2 gas coolant are:

1. The interior of liquid CO_2 pipe, tubing, hose and fittings used between the supply cylinder and the solenoid input valve of the temperature chamber must be kept clean and free of moisture at all times. Any moisture will turn to ice as the liquid CO_2 flows through the lines; the ice can then lodge on the solenoid valve seat or plug the orifice of the valve and cause system malfunction.

2. All low-pressure CO_2 connecting hoses between the supply cylinder(s) and the chamber input valve should be kept as short as possible and should be insulated.

3. The low-pressure CO_2 supply line from the cylinder(s) should be removed prior to use and the line thoroughly dried for best results.

4. The hose connection may be cold after use. In this case, damp ambient air may collect or frost inside the hose. When the hose is connected to the test chamber, this frost is carried into the chamber input valve where a freeze-up may occur, or the frost may be carried directly into the test chamber to form ice crystals on the test object. The CO_2 supply hose must always be clean and dry.

5. If the connecting hose is removed often or has been stored for a period of time, the line and fittings must be examined for presence of chips, rust, or any foreign substances which can jam the inlet valve or plug the valve orifice.

6. A filter is installed in the bulkhead fitting (CO_2 inlet or rear of chamber) and must be checked for cleanliness every 50 hours of operation, or oftener, if necessary. To remove the filter, unscrew the hollow Allen-head screw (item 7 in Figure 3) from the test chamber bulkhead fitting (item 5) and slide the filter (item 6) out of the fitting. Clean the filter in trichloroethylene and dry thoroughly using filtered, moisture-free compressed air at low pressure.

7. It is important that the CO_2 solenoid valve assembly and the orifice be kept clean. The orifice is carefully sized for each application; care should be taken not to ream it larger.

8. The solenoid valve used to inject the CO_2 coolant into the test chamber should "pulse" or actuate rapidly. If the CO_2 valve remains open for long periods of time after pull-down, the chamber may be leaking cold, the test object may be introducing substantial amounts of heat beyond the capacity of the inlet valve orifice, or the temperature set-point may be set below -73.3°C (-100°F). These conditions can cause "snow" to be introduced into the chamber with resultant control problems and possible damage to the chamber and contents. Causes for these conditions should be located and corrected.

Additional precautions:

1. Never install CO_2 supply pipe fittings or valves of a larger internal diameter than those used "upstream" [beginning at the supply cylinder(s)].

2. Do not use fittings which allow undue expansion or restriction of the liquid CO_2. This could cause the CO_2 to reach a critical point where it would expand in the line and cause icing.

3. Do not use excessively long, small diameter supply hoses which might cause the liquid to change to gas in hot areas or during intermittent cycling conditions.

4. Do not meter the CO_2 through any type of valve that has a smaller ID than the supply hose and CO_2 supply cylinder siphon tube. The cylinder supply valve should be fully open during use.

5. It is not possible to utilize all the CO_2 in a siphon-type cylinder. The ambient temperature at the cylinder will determine the amount of CO_2 available (about 95% of maximum). Thus, CO_2 usage may appear to be somewhat higher than it actually is.

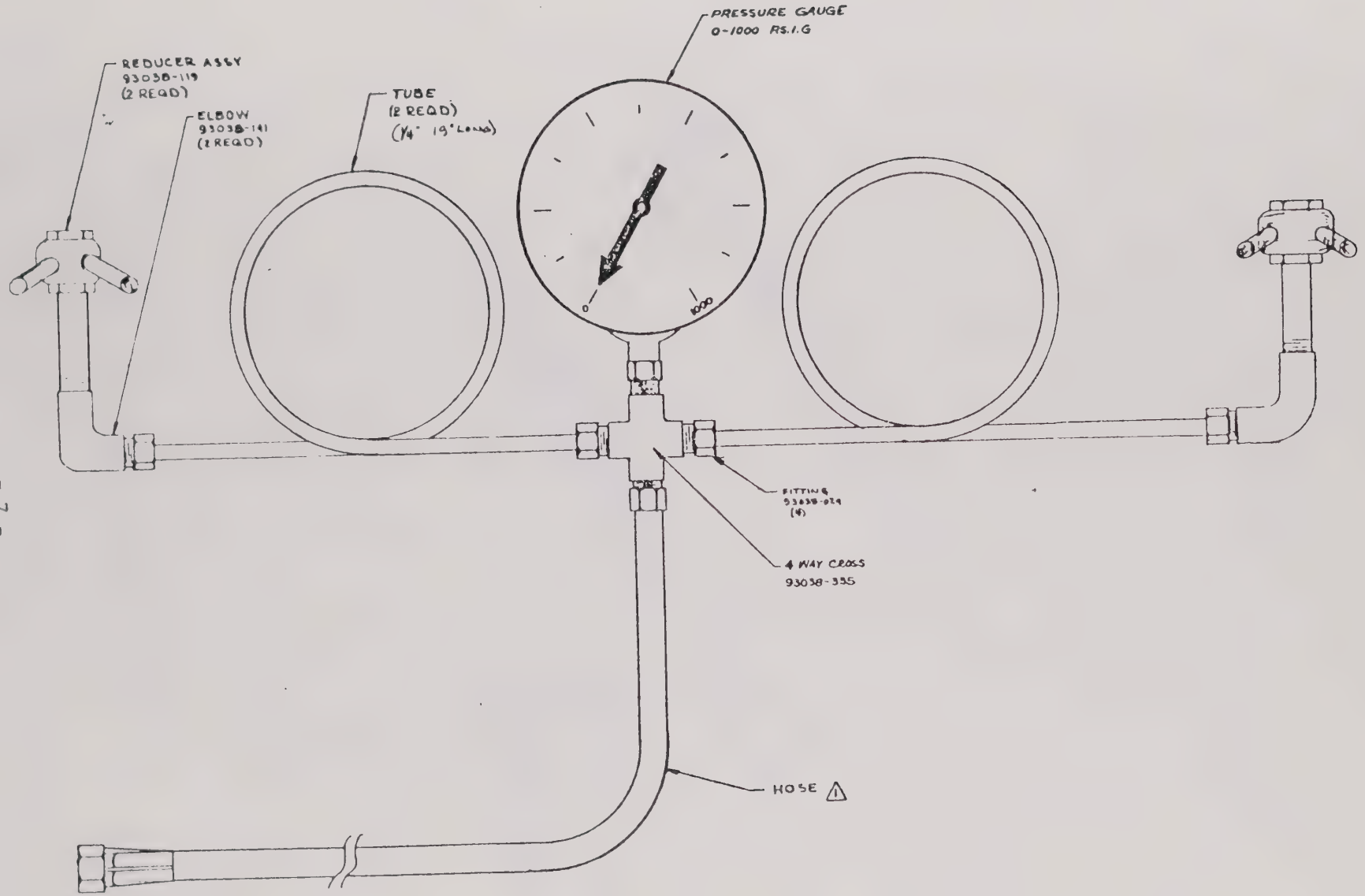

Figure 2

Connections of High or Low Pressure CO_2 Sources

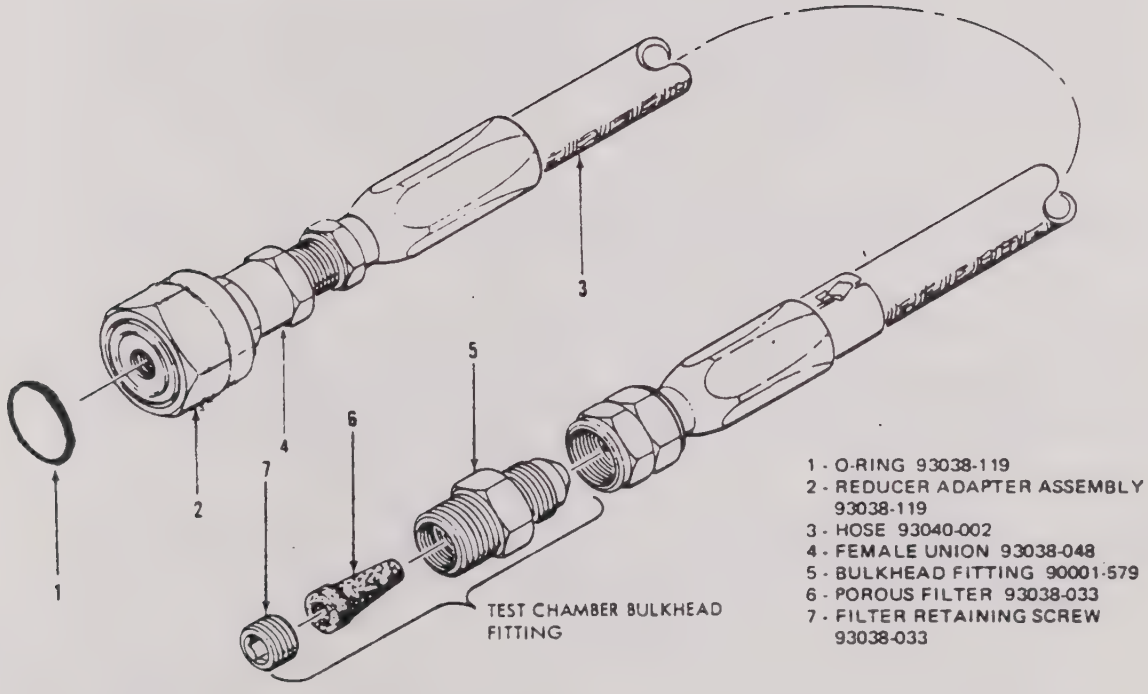

Figure 3. Filter Cleaning
(Typical CO_2 Reducer-Adapter Assembly)

INSTALLATION OF LIQUID CO_2 CYLINDER

For extensive use at low temperatures, it is recommended that two or more liquid CO_2 cylinders be used in parallel as shown in Figure 2. This will increase operating time between cylinder changes. Install the liquid CO_2 cylinder(s) as follows: (See Figures 4 and 5.)

1. Turn off POWER switch and disconnect AC input power.

2. Position the cylinder in a safe and convenient location. Secure the cylinder in an upright position with safety chains.

```
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                WARNING                                  *
*                                                                         *
* Always use heavy safety chains to hold gas cylinders securely in        *
* an upright position. A gas cylinder, damaged by hitting the             *
* floor, can become a dangerous projectile and cause serious damage       *
* or injury over a wide area.                                             *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

3. Carefully crack the cylinder valve slightly before connecting the hose assembly in order to blow out any loose scale or rust which may be in the cylinder.

4. Connect the hand wheel end of the hose assembly to the cylinder.

5. Connect the threaded fitting on the flexible hose to the threaded portion on the chamber bulkhead fitting. The bulkhead fitting must be held in place with a second wrench while the coolant hose is being attached to the bulkhead. See Figure 4.

6. When replacing the CO_2 cylinder, shut off the valve at the cylinder, crack the hose fitting slightly, and allow the residual CO_2 pressure in the hose to bleed off before disconnecting the hose.

USE OF LIQUID NITROGEN (LN_2)

Some models of test chambers use pressurized liquid nitrogen (LN_2) so that lower test temperatures may be reached. Line pressure should be between 55 kPa (8 PSI) and 172 kPa (25 PSI). The following precautions should be observed in handling LN_2:

1. Liquid nitrogen is extremely cold (-196°C or -320°F) at atmospheric pressure and can damage skin or eyes on contact.

2. Asbestos gloves and safety goggles or face plates should always be used in handling LN_2.

3. Clean cotton clothes or lab coats should be worn where LN_2 spillage or prolonged contact with its vapors is a factor.

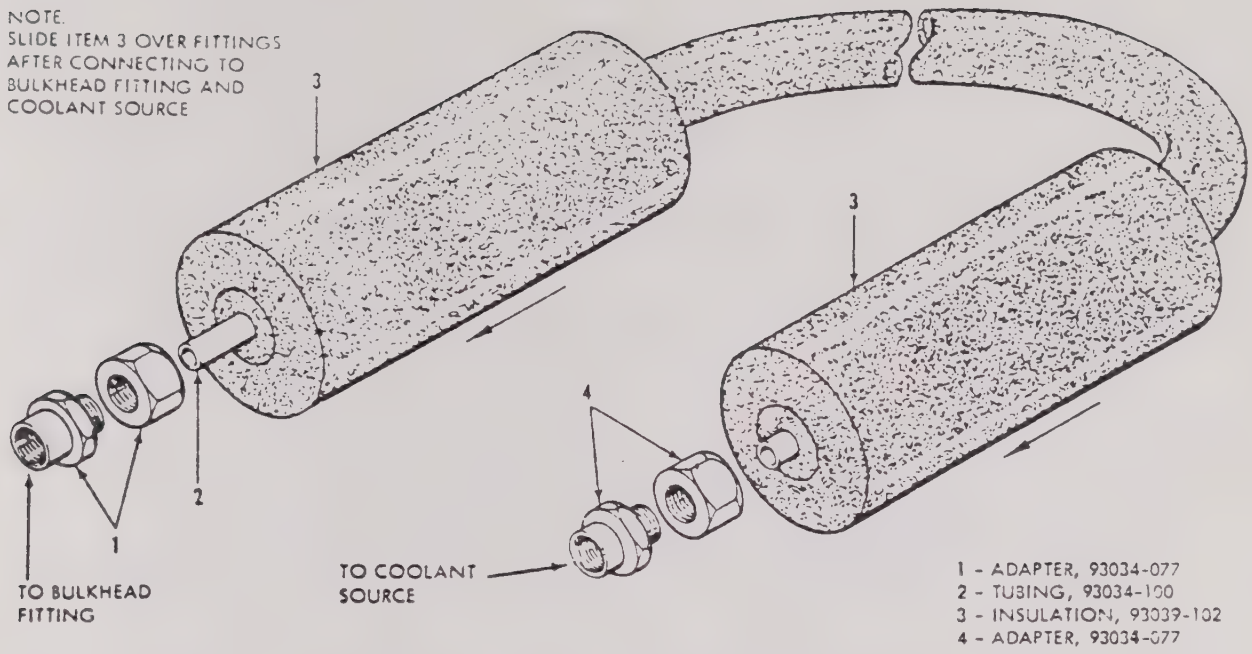

Figure 4. Typical Installation (Removal) of Coolant Hose to (from) Bulkhead Fitting

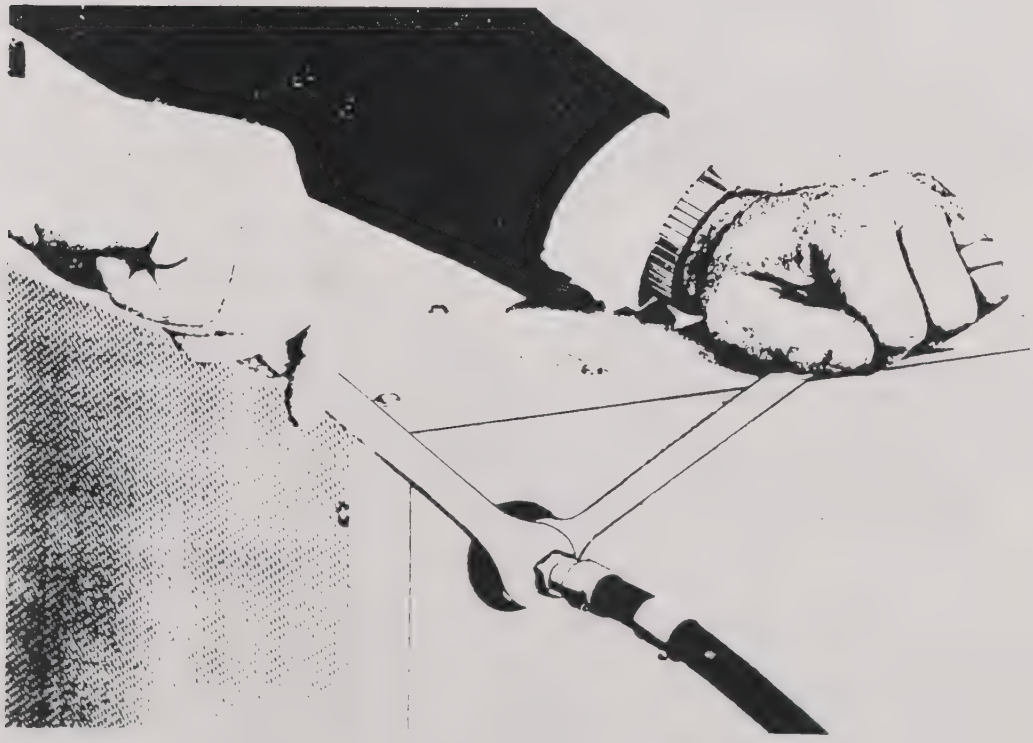

Figure 5. Liquid Nitrogen Hose Assembly

4. Smoking should be prohibited in the immediate area where LN_2 is being handled.

5. All handling equipment such as funnels, dewars, piping, and tubing must be clean, dry, and free of grease.

6. All transfer tubes, valves, and other equipment which reach liquid nitrogen temperatures should be properly insulated with a non-absorbent insulation which is properly contained within a vapor seal.

7. Liquid nitrogen is not in itself explosive or combustible; however, its low temperature will cause condensation of the water vapor in the air and all the gaseous constituents of the air which liquify above -196°C (-320°F), including oxygen. Therefore, supply lines, clothes, and equipment which are subject to this temperature can absorb or liquify oxygen, which will cause a severe fire if ignited and which can become explosive when in contact with grease.

8. LN_2 should not be left in sealed containers or hoses. When th LN_2 turns to nitrogen gas, it will build up very high pressure. Unless LN_2 is being actively used in test chamber operations, care should be taken that an adequate vent is provided and that excessive pressure is bled off.

9. The concentration of liquid oxygen suspended in the LN_2 builds up as the LN_2 is used. Consequently, nearly empty LN_2 containers should be handled as if they were liquid oxygen containers. The presence of liquid oxygen in LN_2 can be determined by the milky appearance of the liquid. LN_2 is normally clear.

10. If parts of the body are frozen by contact with these cold liquids, first-aid treatment for frost bite should be given, with slow thawing of the frozen parts. Severe cases should be referred to a physician for treatment.

INSTALLATION OF LN_2 CYLINDER

The liquid nitrogen cylinder is connected to the test chamber by the hose assembly shown in Figure 5. To prevent ice crystals in the coolant line from entering the test chamber, an ice filter (optional) may be connected between the LN_2 cylinder and the test chamber as shown in Figure 6. The ice filter eliminates ice crystals and prevents them from freezing up valves or intruding into the test chamber. The ice filter should be cleaned periodically by a reverse purge using dry nitrogen. Install the LN_2 cylinder as follows:

1. Turn off POWER switch and disconnect AC power.

2. Position the cylinder in a safe and convenient location.

```
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                WARNING                                  *
*                                                                         *
* Store and use liquid nitrogen only in a well-ventilated area.           *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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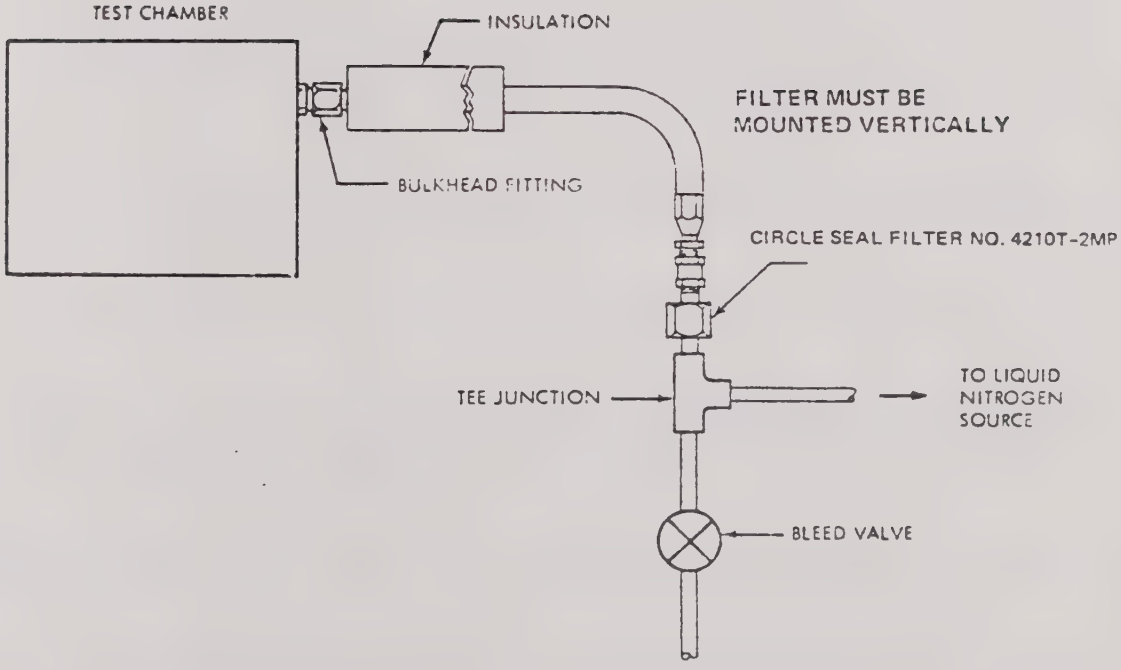

Figure 6. Liquid Nitrogen Ice Filter (Recommended)

3. Connect the cylinder to the test chamber as indicated. The large foam insulation sleeves (item 3 in Figure 5) are pushed over the fitting after the connections have been made. Use a second wrench as shown earlier in Figure 4 to prevent the bulkhead fitting from turning when the connection is being tightened.

COOLING OPERATION

Cooling operations with the temperature test chamber are essentially the same as those for heating operations. If the DRP-13 programmer is to be used, refer to the special instructions included with these options.

1. Attach the test fixture or tray to the chamber.

2. Insure that the POWER switch is off.

3. Plug in the chamber power cord to the correct line power. Avoid adapters that will either unground the chamber or will permit connecting to the wrong power source. Check current rating of circuit.

4. Set the TEMPERATURE SET-POINT to the desired temperature.

5. Turn the POWER switch ON and allow the chamber to cool to the correct operating temperature. The OVERTEMPERATURE SAFETY SET-POINT control is not used during cooling operations.

A relief port has been included in the chamber to protect against excessive internal pressure.

The cooling system will operate efficiently only when there is no vapor lock in the coolant line. Vapor locks can be reduced by keeping the coolant cylinders and lines at the same temperature or by preventing the coolant lines from passing through areas of much higher temperature.

When the chamber is not in use, or when it is used for other than low temperature tests, the valves of the coolant cylinder(s) should be closed to prevent leakage.

After long periods of operation at low temperatures, a certain amount of moisture condenses inside the chamber in the form of snow and frost. Although the insulation in the test chamber is sealed against both internal and external accumulation of moisture, some moisture will eventually collect in the fiberglass insulation. The resulting loss in insulation efficiency tends to decrease cooling rate and increase coolant consumption. To avoid moisture collection in the insulation after sustained operation at low temperatures, the test chamber should be operated for at least one hour at 205°C (400°F) to evaporate the moisture. Do not exceed this temperature with the cryogenic models which are insulated with high-temperature-resistant polyurethane (isocyanate) foamed-in-place resin. This insulation will be damaged if temperatures in excess of 205°C (400°F) are sustained.

SAFETY INFORMATION

Operating and burst pressures for various hose assemblies are given in Table A.

Component	Operating Pressure		Burst Pressure	
	kPa^2	PSI	kPa^2	PSI
CO_2	20,685	3,000	68,950	10,000
LN_2	172	25	2,586	375

TABLE A. OPERATING AND BURST PRESSURES

PERFORMANCE CHARACTERISTICS

Tables B through G list the performance characteristics for Ransco Industries test chambers. The tables are used topically as follows:

1. Find approximate temperature of test chamber in left-hand column.

2. Find temperature desired in second column from left.

3. Determine the CO_2 consumption from the right-hand columns under CO_2 CONSUMPTION.

   Column AIR lists the amount of CO_2 needed to bring the air temperature in the test chamber to the desired degree.

   The AIR + WALLS column lists the associated amount of CO_2 needed to bring the air and the chamber walls to the desired temperature.

   Column RATE/HOUR lists the hourly rate of CO_2 consumption needed to maintain the low temperature.

   The CO_2 consumption in minutes may vary depending on the heat dissipated by the size and material of the test object.

4. Find the minutes needed to reach the desired temperature in the middle columns under MINUTES NEEDED TO REACH TEMPERATURE.

   Column AIR lists the time required for the air in the chamber to reach the selected temperature.

   The AIR + WALLS column lists the associated total time required for the air and walls to reach the selected temperature.

Figure 7 is a performance curve plotting blank. The data in the table for the appropriate test chamber model can be plotted for the temperature changes of interest to better visualize the chamber performance and to interpolate intermediate values.

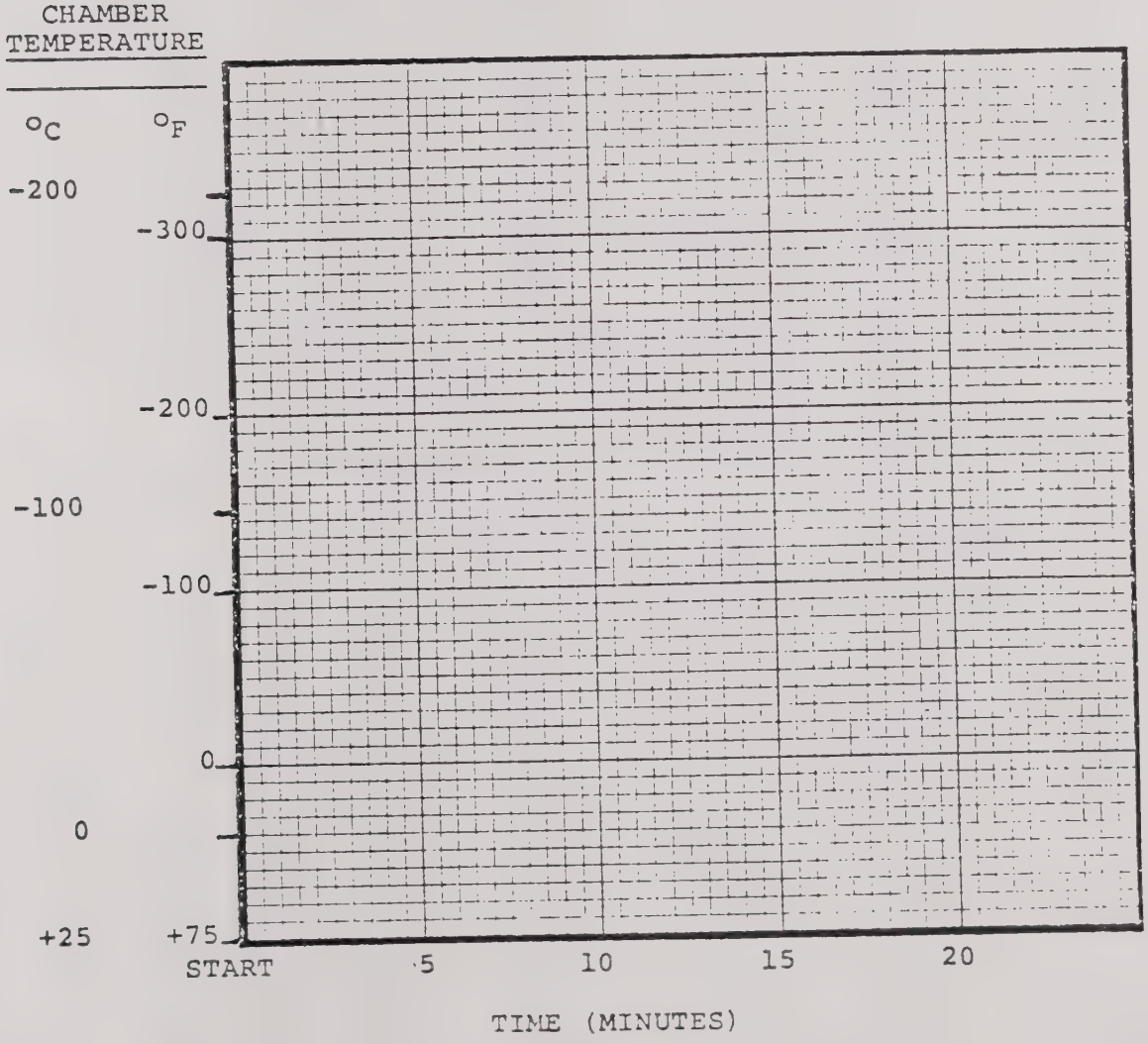

Figure 7. Performance Curve Plotting Blank

Temp. Set Points		Minutes Needed to Reach Temp.		CO_2 Consumption in Pounds (900 psi)		
°C	To	Air	Air + Walls	Air	Air + Walls	Rate/Hr.
+24 to -73	+75 to -100	4.0	13.0	5.0	5.5	8.5
+24 to -45	+75 to -50	3.0	8.0	3.0	3.5	8.0
+24 to -18	+75 to 0	.50	7.0	1.5	2.5	6.0
+24 to +38	+75 to +100	.75	5.0	---	---	---
+24 to +93	+75 to +200	4.5	13.0	---	---	---
+24 to +149	+75 to +300	9.0	18.0	---	---	---
+24 to +204	+75 to +400	13.0	23.0	---	---	---
+24 to +260	+75 to +500	17.0	27.0	---	---	---
+71 to -73	+160 to -100	7.0	12.0	7.0	7.5	8.5
+71 to -45	+160 to-50	6.0	10.0	5.0	6.0	8.0
+71 to -18	+160 to 0	5.0	10.0	4.0	5.0	6.0
+93 to +24	+200 to +75	4.0	8.5	3.0	3.5	4.5
+149 to +24	+300 to +75	5.0	10.0	5.0	5.5	4.5
+204 to +24	+400 to +75	7.0	12.0	6.5	7.0	4.5
+260 to -59	+500 to -75	10.0	13.0	10.5	13.0	8.5
+260 to -73	+500 to -100	16.0	19.0	12.0	14.0	8.5
-73 to +24	-100 to +75	6.0	9.0	---	---	---
-73 to +260	-100 to +500	22.0	32.0	---	---	---

TABLE B. PERFORMANCE CHARACTERISTICS, MODEL 925

Temp Set Points		Minutes Needed to Reach Temp.		LN_2 Consumption in Pounds		
°C	°F	Air	Air + Walls	Air	Air + Walls	Rate/Hr. C
+24 to -18	+75 to 0	3.75	7.0	2.5	3.0	10.25
+24 to -45	+75 to -50	4.5	8.5	3.5	4.0	11.0
+24 to -73	+75 to -100	6.0	10.0	4.0	5.0	12.75
+24 to -100	+75 to -150	7.0	11.0	6.25	7.0	15.0
+24 to -129	+75 to -200	8.0	11.5	7.5	8.5	17.5
+24 to -150	+75 to -250	10.0	12.0	9.0	10.5	18.0
+24 to -184	+75 to -300	12.5	15.0	10.5	14.0	20.0
+24 to +38	+75 to +100	1.5	3.5	---	---	---
+24 to +93	+75 to +200	3.5	6.0	---	---	---
+24 to +149	+75 to +300	7.0	11.0	---	---	---
+24 to +204	+75 to +400	12.0	23.0	---	---	---
+93 to -73	+200 to -100	8.0	11.0	6.0	7.5	12.75
+93 to -129	+200 to -200	9.0	11.5	9.5	12.0	17.5
+93 to -184	+200 to -300	13.0	16.75	14.25	18.0	20.0
+93 to +24	+200 to +75	6.5	9.0	3.5	4.0	---
+204 to -129	+400 to -200	15.5	18.0	13.5	15.0	17.5
+204 to -184	+400 to -300	17.5	20.0	19.0	20.0	20.0
-184 to +24	-300 to +75	13.5	16.5	---	---	---
-184 to +204	-300 to +400	19.0	35.0	---	---	---

TABLE C. PERFORMANCE CHARACTERISTICS, MODEL 935

Temp. Set Points		Minutes Needed to Reach Temp.		LN_2 Consumption in Pounds		
				Amount by Stages	Total	Rate/Hr.
°C	°F	A (Air)	Air + Walls	A (Air)	Air + Walls	C
+24 to -18	+75 to 0	2.0	0.9	1/4	3/4	6-1/4
+24 to -45	+75 to -50	4.5	11.0	1-3/4	2-1/2	7-1/2
+24 to -73	+75 to -100	5.0	12.0	2-1/4	3	8
+24 to -100	+75 to -150	6.5	13.0	2-3/4	4	9-3/4
+24 to -129	+75 to -200	7.0	14.0	4	4-3/4	10-3/4
+24 to -150	+75 to -250	8.0	14.5	5	6-1/4	12
+24 to -184	+75 to -300	8.5	15.0	5-1/2	6-1/2	13
+24 to +38	+75 to +100	1.0	4.5	--	--	--
+24 to +93	+75 to +200	3.5	16.0	--	--	--
+24 to +149	+75 to +300	10.0	30.0	--	--	--
+24 to +204	+75 to +400	12.0	41.0	--	--	--
+93 to -73	+200 to -100	6.0	19.0	1-3/4	3-3/4	8
+93 to -129	+200 to -200	8.0	22.0	3-1/2	5-3/4	10-3/4
+93 to -184	+200 to -300	9.0	23.0	5-1/2	9	13
+93 to +24	+200 to +75	2.5	10.0	3/4	1	--
+204 to -129	+400 to -200	11.0	24.0	7	10	10-3/4
+204 to -184	+400 to -300	13.0	26.0	8	11	13
-184 to +24	-300 to +75	3.5	13.0	--	--	--
-184 to +204	-300 to +400	8.0	50.0	--	--	--

TABLE D. PERFORMANCE CHARACTERISTICS, MODEL 934

Temp. Set Points		Minutes Needed to Reach Temp.		CO_2 Consumption in Pounds (900 psi)		
				Amount by Stages	Total	Rate/Hr.
°C	°F	A (Air)	Air + Walls	A (Air)	Air + Walls	C
+24 to -73	+75 to -100	4.0	11.0	2.4	3.8	5.0
+24 to -45	+75 to -50	2.0	8.0	1.9	2.8	4.5
+24 to -18	+75 to 0	1.0	5.0	1.4	2.7	4.0
+24 to +38	+75 to +100	0.5	3.0	--	--	--
+24 to +93	+75 to +200	2.0	12.0	--	--	--
+24 to +149	+75 to +300	5.0	22.0	--	--	--
+24 to +204	+75 to +400	8.0	26.0	--	--	--
+24 to +260	+75 to +500	12.0	32.0	--	--	--
+71 to -73	+160 to -100	6.0	21.0	3.6	6.4	5.0
+71 to -45	+160 to -50	4.0	14.0	2.2	4.2	4.5
+71 to -18	+160 to 0	2.0	8.0	1.8	2.1	4.0
+93 to +24	+200 to +75	2.0	11.0	1.1	1.4	--
+149 to +24	+300 to +75	3.0	18.0	2.2	3.1	--
+204 to +24	+400 to +75	5.0	38.0	3.0	4.5	--
+260 to -59	+500 to -75	7.0	52.0	4.0	6.7	--
+260 to -73	+500 to -100	12.0	67.0	8.3	10.5	5.0
-73 to +24	-100 to +75	3.0	8.0	--	--	--
-73 to +260	-100 to +500	20.0	45.0	--	--	--

TABLE E. PERFORMANCE CHARACTERISTICS, MODEL 924

Temp. Set Points		Minutes Needed to Reach Temp.		LN_2 Consumption in Pounds		
				Amount by Stages	Total	Rate/Hr.
°C	°F	A (Air)	Air + Walls	A (Air)	Air + Walls	C
+24 to -18	+75 to 0	3.0	12.0	1-3/4	3	5-1/4
+24 to -45	+75 to -50	5.0	13.5	3-1/4	5-1/4	8-3/4
+24 to -73	+75 to -100	6.0	16.0	5	7-1/2	12-1/4
+24 to -100	+75 to -150	7.5	18.0	7	9-3/4	15-1/2
+24 to -129	+75 to -200	8.0	20.0	8-1/2	12	18-3/4
+24 to -150	+75 to -250	10.0	22.0	10-3/4	15-1/4	22-1/4
+24 to -184	+75 to -300	12.0	24.0	13	18	25-3/4
+24 to +38	+75 to +100	1.5	9.0	--	--	--
+24 to +93	+75 to +200	4.0	20.0	--	--	--
+24 to +149	+75 to +300	9.0	38.0	--	--	--
+24 to +204	+75 to +400	16.0	53.0	--	--	--
+93 to -73	+200 to -100	10.0	26.0	6-1/2	11	12-1/4
+93 to -129	+200 to -200	15.0	31.0	13	19	18-3/4
+93 to -184	+200 to -300	18.0	36.0	19	26-1/4	25-3/4
+93 to +24	+200 to +75	7.0	19.0	2-1/4	3-1/4	--
+204 to -129	+400 to -200	18.0	47.0	17-1/2	26	18-3/4
+204 to -184	+400 to -300	22.0	50.0	22	33	25-3/4
-184 to +24	-300 to +75	13.0	22.0	--	--	--
-184 to +204	-300 to +400	28.0	65.0	--	--	--

TABLE F. PERFORMANCE CHARACTERISTICS, MODEL 936

Temp. Set Points		Minutes Needed to Reach Temp.		CO_2 Consumption in Pounds (900 psi)		
				Amount by Stages	Total	Rate/Hr.
°C	°F	A (Air)	Air + Walls	A (Air)	Air + Walls	C
+24 to -73	+75 to -100	4.00	20.00	6.0	10.0	9.0
+24 to -45	+75 to -50	1.75	13.00	3.0	5.5	7.0
+24 to -18	+75 to 0	1.00	6.00	1.4	1.5	5.0
+24 to +38	+75 to +100	0.75	4.50	--	--	--
+24 to +93	+75 to +200	4.00	22.00	--	--	--
+24 to +149	+75 to +300	6.75	45.00	--	--	--
+24 to +204	+75 to +400	11.10	64.00	--	--	--
+71 to +260	+75 to +500	16.75	82.00	--	--	--
+71 to -73	+160 to -100	4.30	21.00	7.5	13.0	9.0
+71 to -45	+160 to -50	3.50	18.00	4.5	9.0	7.0
+71 to 0	+160 to 0	1.75	14.00	2.7	7.0	5.0
+93 to +24	+200 to +75	1.80	10.00	2.0	9.0	--
+148 to +24	+300 to +75	2.00	18.00	2.5	12.5	--
+204 to +24	+400 to +75	3.00	26.00	6.5	15.5	--
+260 to -59	+500 to -75	10.00	43.00	14.0	23.0	--
+260 to -73	+500 to -100	12.00	50.00	15.0	25.0	9.0
-73 to +24	-100 to +75	3.25	32.00	--	--	--
-73 to +260	-100 to +500	20.00	120.00	--	--	--

TABLE G. PERFORMANCE CHARACTERISTICS, MODEL 926

IV

THEORY OF OPERATION

INTRODUCTION

This section contains a functional as well as a detailed circuit description of the temperature control circuits in all models of these temperature test chambers. See Figure 10 for block diagram and circuit diagram information.

FUNCTIONAL DESCRIPTION

The Ransco Industries Temperature Test Chamber uses a closed airflow system to transfer heat to or from objects under test. A low inertia electric coil heater is used for elevated temperatures in the chamber. Cooling of the chamber is accomplished by injecting liquid carbon dioxide or liquid nitrogen into the test chamber, where the coolant rapidly evaporates. The operating temperature of the test chamber is determined by the setting of the Set-point switches.

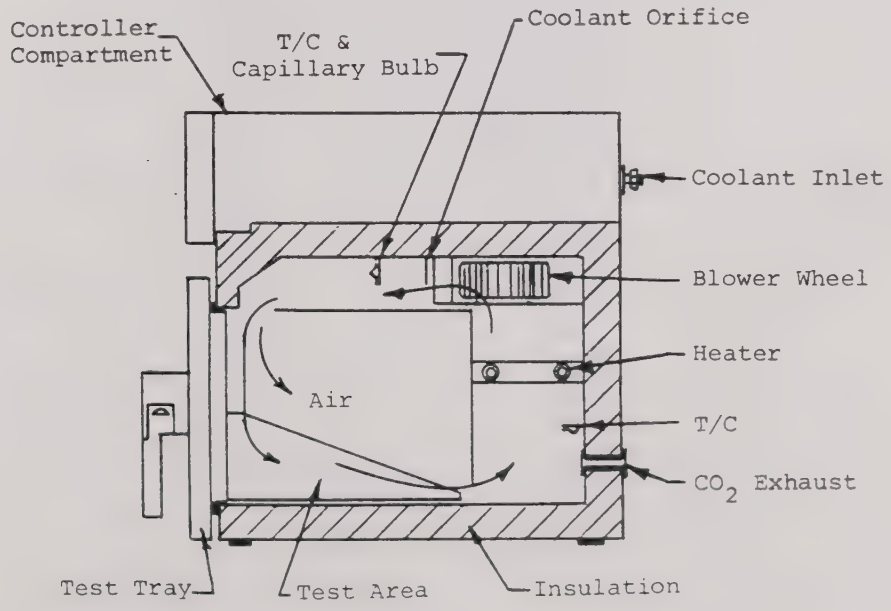

Figure 8. Air Flow in Temperature Test Chambers, Models 925 and 935

Temperature sensing elements in the chamber allow the control to automatically maintain the chamber temperature at the value indicated on the setpoint switches. A comparator circuit activates the heat or cooling as necessary.

An automatic mode-switching circuit ensures that only one function, heating or cooling, is in operation at any one time. This eliminates the possibility of the heat control circuit opposing the cool control circuit.

An overtemperature safety circuit protects the test chamber and test objects by removing all power when the test chamber exceeds the maximum rating of the chamber (274°C).

An adjustable high limit allows the maximum operating temperature to be selected or varied for each test. This dial type unit will interrupt the power to the heater if the chamber temperature exceeds the high limit setting.

The detailed description of the temperature control circuits is similar for all test chamber models; therefore, only the temperature control circuit for Model 924 is discussed in detail.

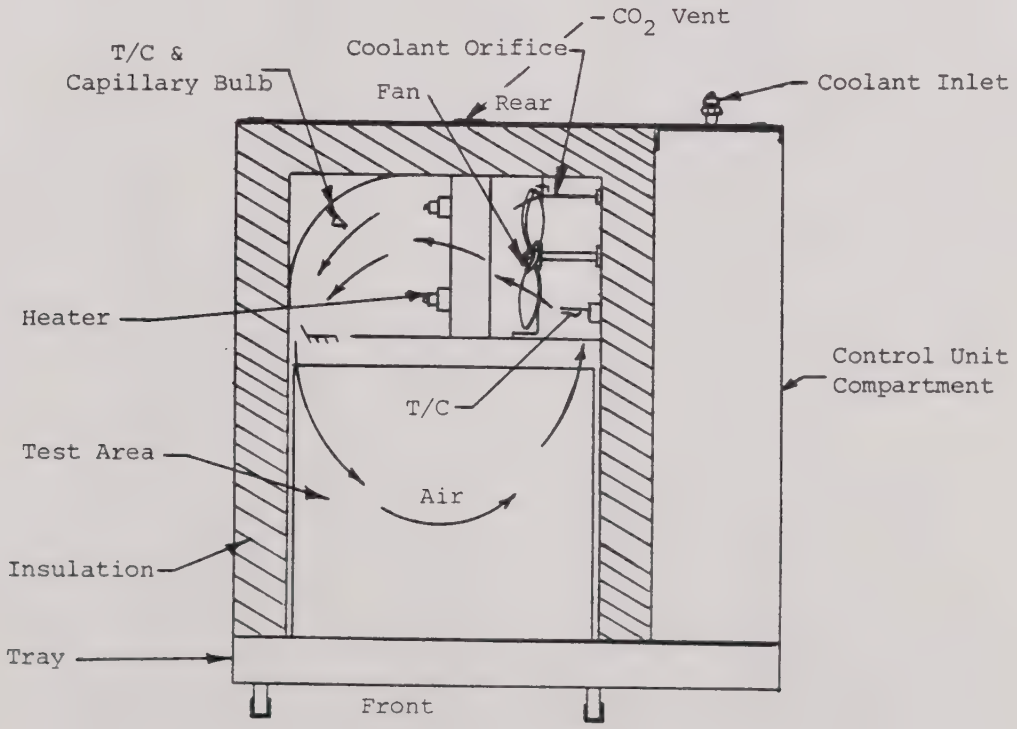

Figure 9. Air Flow in Temperature Test Chamber, Models 934 and 924 (Basically the same as in 936 and 926 which also have horizontal air flow)

Models 935, 934 and 936 use two additional heaters: HTR2 located under the opening gasket of the chamber and HTR3 located on the shaft bushing of motor B2. Heater HTR2 is controlled by thermoswitch S2, which is set at +10°F ±5°F.

The thermoswitch is located on the rear of the Transite liner and senses the door opening temperature of the liner and door opening frame assembly. The heaters prevent the test tray door from frosting excessively, the door seal from freezing, and motor B2 from becoming inoperative at temperatures of -300°F. When the temperature test chamber is not being operated at extremely low temperatures, thermal switch S2 is open, disabling HTR2 and HTR#.

230V, 50/60 Cycle operation

230V Models 925, 935, 934, 924, 936 and 926 are identical in operation to their respective 115V models.

Figure 10

V

RDC CONTROLLER

INTRODUCTION

The Ransco RDC Double Adaptive Temperature Controller is a high-precision, microcomputer based temperature controller which uses digital techniques to control temperature systems. It has no moving parts such as cams, gears or slide wires. The controller's adaptive capability lets it change control parameters automatically, allowing the controlling action to adapt to the thermal response characteristics of the controlled environment in both the heat up and cool down phases. Brown-out protection for the microcomputer is built in, as well as open thermocouple detection circuitry.

The controller's microcomputer automatically regulates heat and coolant in the controlled environment by providing time proportioning or power proportioning outputs.

Input to the controller is from two type T thermocouples. The microcomputer compares the signal from the thermocouple to the setpoint selected on the digital thumbwheel switches. The difference is determined by subtracting the system temperature from the setpoint.

Other digital functions are also performed, including integral feedback, and correction of the non-linearities in the thermocouple's response. The controller uses these calculated values to automatically adjust variables in its temperature control program. This improves the settling characteristics of a system and results in precise control, steady rates of temperature change, reliable repeatability and high stable control at the setpoint.

Function

The signal from the thermocouple is amplified by a differential DC solid state feedback amplifier and is applied to the input of a 12 bit dual slope A/D converter. The A/D converter incorporates automatic zero drift compensation and has a conversion rate of 7.5 per second. The converted sensor output signal is processed by the controller's microcomputer.

System temperature is continuously displayd to 0.1° for Celsius and Kelvin (.2° Fahrenheit). The digital control mode is like proportional and integral control.

Related Ransco Equipment

IEEE-488 Double Port Interface

The Double Port Interface may be used to set temperature, read temperature and issue commands to the temperature controller. It includes two independent ports so that two temperature controllers or one temperature controller and one piece of additional equipment may be operated by a buss controller such as the Fluke 1720A Instrument Controller, the HP9825, or the Commodore PET Microcomputer.

Ransco Set-Point Programmer, Model RDP-13:

Temperature sequences, including rate of temperature change, setpoint temperature, duration at a particular temperature and three external events may be pre-programmed using the Ransco Set-point Programmer. A built-in digital connector on the temperature controller permits easy interface of the two units.

Specifications

Repeatability:	±0.15°C (±0.28°F)
Cold Junction Compensation:	Built-in, 0.03°/degree ambient
Control Mode:	Digital - like PID control
Display Update Rate:	7.5 readings per second
Power:	117 VAC, 50/60 Hz, 15 W
Calibration:	Ambient and full scale
Proportioning Automatic Heat-Cool	
Time Proportioning Period:	1 second
Heat and Cool Outputs:	Logic outputs, maximum load voltage 40 VDC, 100 MA maximum sink. (Suitable for driving photo-isolated solid state relays.)
Fixed Deviation Limit Output:	Logic output 100 MA, maximum sink. Switches beyond ±1.6°C from setpoint.

INSTALLATION

Interface

Thermocouple:

Type "T" thermocouples which are installed in the controlled environment must be connected at TB 1 at the top in the middle of the controller circuit board. A label specifies where the + (blue) and - (red) wires connect.

Double Port Interface (IEEE-488):

When the temperature controller application calls for all equipment to be operated by a buss controller or similar equipment, interconnection with the Double Port Interface is required. This is accomplished by connecting the interface cable to the remote connector (J1) on the back panel. Refer to the Double Port Interface instruction manual for additional installation guidelines before proceeding.

Ransco Set-Point Programmer (DRP-13):

Interconnection between the temperature controller and set-point programmer is accomplished with the cable provided with the programmer (J1) on the back panel of the chamber.

Calibration

The Ransco RDC controller is calibrated at the factory. Should it be necessary to recalibrate a unit, the following procedure is recommended:

Equipment Required:

Thermocouple calibrator or potentiometer

Procedure:

1. Remove heater fuse (20 amp).

2. Disconnect chamber themocouples and install Type T thermocouple wire from calibrator to control.

Ambient Calibration:

1) Turn on calibrator and chamber.

2) Adjust calibrator to give an output equivalent to 20.0°C.

3) On the controller p.c. board, adjust the AMBIENT pot (R24) until the reading on the digital display of the temperature controller matches the setting of the calibrator (20.0°C).

Full Scale Calibration:

1) Adjust the calibrator to give an output equal to 174.0°C.

2) Adjust the SLOPE pot (R9) on the controller p.c. board until the display reading matches the setting on the calibrator (174.0°C).

Calibration is now complete.

Calibration may be verified by randomly selecting temperatures. Set the calibrator and verify that the displayed temperature matches the calibration value.

Refer to Figure 11 for location of calibration adjustments.

Reinstall chamber thermocouples.

Replace chamber heater fuse. Chamber is now ready for use.

This calibration may be performed using the RANSCO Temperature Controller Diagnostic Chip, part no. S1021A. Standard calibration procedures may also be used; both methods are outlined here.

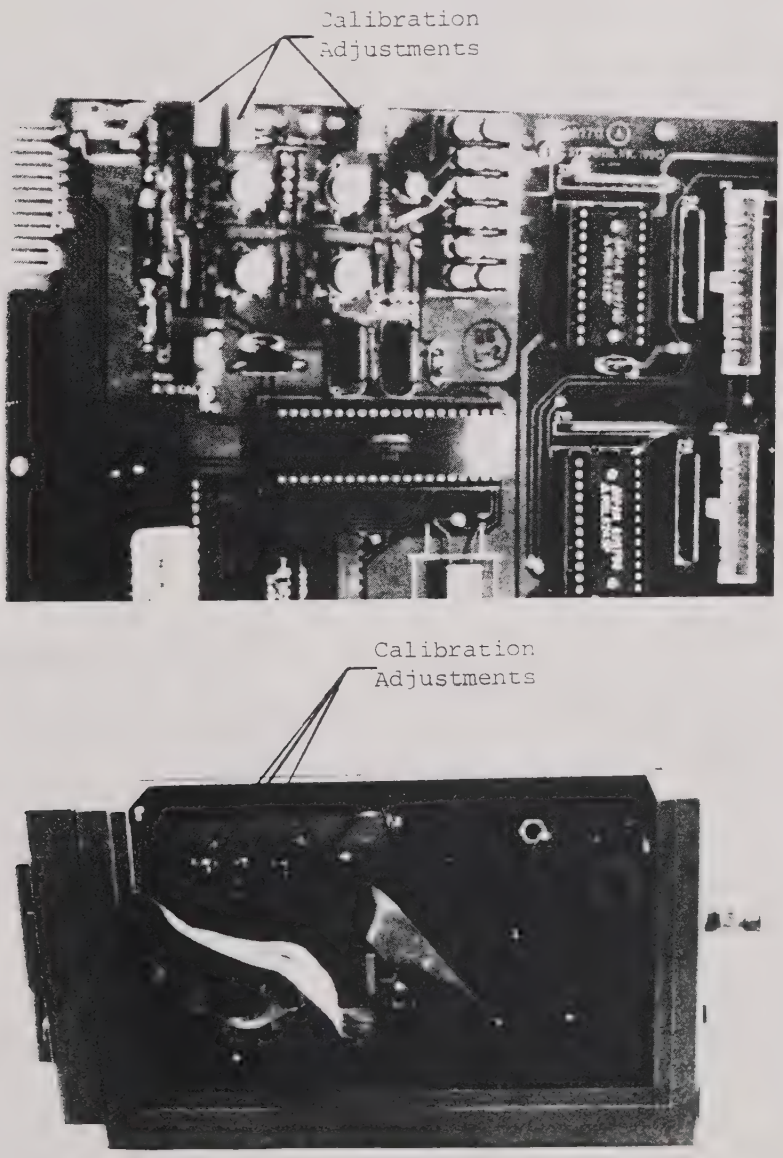

Figure 11

USING THE COMPUTER INTERFACE PORT

REMOTE DIGITAL INTERFACE
(ON REAR PANEL)

Pinouts	and	Functions
1		.1 Tenths
14		.2 Tenths
2		.4 Tenths
15		.8 Tenths
3		1 Units (BCD)
16		2 Units
4		4 Units
17		8 Units
5		10 Tens (BCD)
18		20 Tens
6		40 Tens
19		80 Tens
7		100 Hundreds (BCD)
20		200 Hundreds
8		400 Hundreds
21		Minus Temperature
9, 10, 22, 23		Logic Common
11		Do Not Use
24		Read Temperature Command (LO = Read Temperature)
12		Remote Control (LO = Remote)
25		Setpoint Valid Command (HI = BCD Lines Have Valid Data)
13		Do Not Use

Output Drive Capability

Output Drive capability on pins containing BCD data - outputs are from Intel 8243 I/O device with 22K pull up resistor to +5 VDC. Logic HI true on BCD information lines.

Command Input Lines

Command INPUT lines (PINS 12, 24 and 25 connected to NMOS inputs with 10K to 22K pull up resistors to 5 VDC.

Input Interface

Input interference from the computer must be 5 volt logic levels with "0" volts connected to controller logic common.

Description of Operation of the Remote Digital Interface

The interface to the temperature controller is relatively simple. The microcomputer on the temperature control looks for four decades of BCD information on an I/O port (actually an Intel 8243 device). The microcomputer thus determines the system SETPOINT as information present at the inputs to the 8243 I/O.

A SETPOINT VALID input signal from the interface connector is utilized to convey information to the processor regarding the validity of the BCD information at the input to the 8243 I/O chip. A HI Setpoint Valid signal is an indication to the processor that the information at the input to the 8243 chip is valid and is not changing.

Dropping the Setpoint Valid signal tells the processor that the BCD information at the input to the 8243 I/O chip will remain valid for an additional 80 microseconds minimum and causes the processor to store the setpoint information in internal RAM memory for reference until the DATA VALID line goes HI again.

Two separate "Setpoint I/O" devices are provided on the controller. The selection of the I/O device utilized to read the required SETPOINT is determined by the logic level on the REMOTE CONTROL INPUT (Pin 12 on the Computer Interface Receptacle). A LO logic level selects the I/O chip Z15 (connected directly to the Remote Temperature socket J5 on the circuit board assembly.) A HI logic level on pin 12 of the rear panel interface receptacle causes the computer to read its SETPOINT from I/O device Z4 and the related panel Mounted Digitswitch.

When the controller is used in an environment where all of the setpoint input is via the remote digital interface. Pin 12 should be taken LO and kept in the LO state and the setpoint latched on the I/O BCD lines. In this manner, the current SETPOINT is the four decade BCD information connected to the remote digital interface.

NOTE: Please observe that the pinouts on the board mounted receptacle (P5) do not agree with the pinout numbers on the Remote Digital Interface Connector which is located on the rear panel of the chamber. The lines in the ribbon cable correspond to the pinouts on J5 (the p.c. mounted receptacle on the circuit board). The Remote Digital Interface is a "ribbon cable" mass terminated "D" subminiature 25 pin receptacle and the mass termination results in the pinouts on the connector not following lines in the ribbon cable.

Writing a Setpoint To the Temperature Controller Via the Remote Digital Interface

1) Line 12 must be LO and kept LO (logic 0 causes use of the I/O device (Z15) associated with the Interface).

2) Latch the BCD Setpoint information onto the data lines of the Interface. (HI = logic true).

Reading the Process Temperature Via The Remote Digital Interface

Reading the system temperature via the Interface consists of five steps:

1) Take the Setpoint Valid Line LO to the Interface (Pin 25). Keep the data on the BCD lines latched for another 120 microseconds so as to allow the microcomputer of the temperature controller to store the Setpoint in its internal memory.

2) Tri-state the data lines connected up to the BCD connections on the Controller Interface. This gets the user's computer ready to read the data that the temperature controller will output on the interface port.

3) Take the READ TEMPERATURE line LO (Pin 24) and look for the BCD character to appear on the Most Significant Decade (MSD) as that is the indication that the information is present at the output. Until the information is ready to be read, the information present at the MSD (pins 21, 8, 20, and 7) will be all logic highs (F hex).

4) Take the READ TEMPERATURE LINE HI (Pin 24). This action latches the data on the output of the Temperature Controller and the latched data can be read without any concern about it changing in the middle of the computer read.

5) After the data is read, take the SETPOINT VALID line HI and latch the setpoint data on the data lines for the Temperature controller.

An alternative to the above procedure is to follow the steps 1 and 2 above then proceed as follows:

6) Take the READ TEMPERATURE line LO and then wait for 330 milliseconds then take the READ TEMPERATURE line HI.

7) Wait for 60 microseconds then read the Setpoint Temperature on the BCD data lines. This data has been latched and the last 60 microseconds wait insured that the data was stable and not changing.

8) After the data has been read, take the SETPOINT VALID line HI and latch the Setpoint BCD data on the data lines going to the Remote Digital Interface.

OPERATION

Power Up

Power to the controller is supplied through the chamber. The heat and cool lights will come on and the controller will immediately begin to reach the setpoint temperature when the chamber power switch is turned on.

Heat and Cool Lights

The heat light is on solid while the controller is calling for heat. When the setpoint is reached, the light blinks, if some heat is required to maintain temperature.

The cool light is on solid while the controller is calling for cooling. When the setpoint is reached, the light blinks, if some cooling is required.

Remote Mode

The REMOTE connector on the back of the chamber is designed so that taking Pin 12 (Remote Interface Control) low puts the temperature controller in the Remote Mode. This may be done intermittently, depending on the type of equipment interfaced.

This connector is used with the Ransco Set-point Programmer, Temp Certifier, Double Port IEEE-488 Interface or special application programs. It accepts 16 lines I/O and two handhshake lines. The I/O lines may be steady state (BCD), latched input or bidirectional computer interface.

Temperature Setpoint Switch

Five thumbwheel switches are provided for setting temperature. The first switch sets plus or minus, the remaining four set temperature with a fixed resolution of 0.1°.

Overrange protection is built in so that if a temperature that is out of range is dialed on the setpoint switches, "----" appears on the display.

Temperature Display

Actual system temperature is digitally displayed continuously on the front panel. This shows ACTUAL system temperature while the setpoint temperature is indicated on the thumbwheel switches.

If a Set-point Programmer is being used, refer to the Set-point programmer manual for an explanation of front panel indications.

Normal Operation

All temperature control functions occur automatically after power is turned on.

Shutdown

To turn off the temperature controller, simply turn off system power.

Failure Modes

The display on the front panel to the controller will give the following error messages:

P.OP = probe open

If the temperature controller's probe opens, the controller's heat and cool outputs are automatically turned off.

MAINTENANCE AND REPAIR

Keep the interior of the controller relatively clean. Stray bits of wire can cause shorting and damage to components.

Replacing Modules

Functions in the temperature controller are performed by p.c. board modules. If a faulty module is suspected, it can be easily removed and replaced.

Replacing Thermocouple

If a thermocouple opens, it is easily removed and replaced with another thermocouple at TB1.

Recalibration

Recalibration is seldom necessary. However, it is recommended that calibration be checked once a year.

Non-Routine Repairs

Removal of the microprocessor from the socket is normally not necessary. Its removal will void the warranty unless the factory has been consulted previously, and authorization has been approved.

Diagnostic Chip

An optional diagnostic chip may be used to exercise the controller and check analog and digital operations.

This chip is designed for use when the user desires to provide maintenance and repair of the temperature controller rather than returning it to the factory. It requires removal of the microprocessor from the temperature controller's main board. Before using the chip, contact the factory to obtain authorization and instructions on removing the microprocessor. Unauthorized removal of the microprocessor voids the warranty.

Diagnostic Procedure Using S1021A Chip

1) Switch AC power off and unplug any accessories connected to the controller such as a Set-point Programmer or IEEE-488 interface.

2) Install the diagnostic program IC (S1021A) in socket Z1 on the controller board.

3) Dial +000.0 (or +0000) on the setpoint switch and switch on the controller's AC power.

4) Verify that each digit of the temperature display cycles through its entire character set (0-9, -, E, H, L, P) except for the most significant digit, which will not display the character "0". After cycling the display, the diagnostic program will momentarily turn on decimal point 1 (xxx.x), decimal points, the NULL, HEAT, and COOL outputs in sequence.

NOTE: DIALING A "1" IN THE LEAST SIGNIFICANT SETPOINT DECADE CAUSES THE PROGRAM TO EXPEDITE TO STEP 4. DIALING A "9" CAUSES IT TO SKIP STEP 4.

5) Upon completion of Step 4, the program will echo the number dialed on the setpoint switch back to the display. Decimal point 1 (xxx.x) will be on.

NOTE: IF ANY OF THE SPECIAL CODES (-37XX) CALLED FOR IN THE FOLLOWING STEPS ARE DIALED ON THE SETPOINT SWITCHES, THE PROGRAM WILL EXIT IN STEP 5.

6) Dial -3700 on the setpoint switches. The status of the A/D converted "data valid" output will appear on the temperature display as an alternating "H" and "L", indicating a logic high and low, respectively. As this cycle repeats 7-1/2 times per second, a flicker is barely discernible.

7) Dial -3701. The A/D converter data output will appear on the display in decimal form. The range of its output extends from -4095 to +4095 decimal. An input voltage greater than that which generates +4095 will cause the message, "P.OP" to appear on the display. This indicates that the converter's FAIL output is operating properly.

NOTE: NEGATIVE DISPLAYS WILL NOT SHOW THE THOUSANDS DIGIT, AS THAT SPACE IS OCCUPIED BY THE SIGN. THE DIFFERENTIAL AMPLIFIER WILL TYPICALLY LIMIT THE NEGATIVE RANGE TO SOMETHING HIGHER THAN THE -4095 POINT.

8) Dial -3702. The "H"'s will appear on the display. If the pads for jumper A on the controller board are shorted together, the left hand "H" will change to "L", indicating a logic low, or ground on Z1-34. If the Setpoint valid line on the Remote Digital Interface is grounded, the right hand "H" will change to an "L". The latter two checks can be used to verify correct operation of the interface handshake lines.

9) Dial -3712. This code causes suppression of the program's autocheck "heartbeat" output, simulation entry into a "limbo" state or illegal endless loop. Absence of the autocheck heartbeat for 4 seconds causes the auto-restart circuit, Z2, to issue a power ON reset to the CPU to enable it to recover. The program will then revert to the operation described in step 4.

10) Dialing a -3711 at any time causes operation to revert to that described in step 4.

11) All hardware operation has been verified except for the bidirectional computer interface and differential amplifier and cold junction calibration. An error in normal operation not detected by the above procedure required replacement of the temperature controller program IC in socket Z1.

Bidirectional computer interface operation can be verified by switching the two 8243 chips on the temperature controller board and repeating steps 1-10. Replace the chips to their original locations when the procedure has been completed.

RDC

USING S1021A CHIP DIAGNOSTIC CHECKS

Dial	Test Description	Symptoms	Check
+0000	Exercises outputs, slow.	Incorrect display sequence.	Display assembly, Z9.
		Display does not change.	Display assembly, Z9, XTAL1, Z4, Z3, Z2, C7.
		Display remains blank.	+5V supply (Q2).
		Incorrect cool output.	Z17, Q4, Z9.
		Incorrect heat output.	Z17, Q5, Z9.
		Incorrect null output.	Z17, Q6, Z9.
+0001	Exercises outputs, fast.	Same as above.	Same as above.
+0009	Jump to setpoint echo test. Setpoint Echo Test.	Incorrect echo on display.	Thumbwheel switch assembly Z10, Z16.
-3700	A/D "Data Valid" Output.	"H" and "L" not alternately flickering.	Z4, -5V supply.
-3701	A/D output display.	Display does not function as described in step 7.	Z4, -5V supply, analog circuitry.
-3702	Handshake input test.	Display does not function as described in step 8.	Check continuity to Z1-1, 6, 34 and to ground.
-3712	Auto Restart Test.	No auto restart.	Z2, Z3, Z9, CR2, C7.
-3711	Return to exercise outputs tests.	N/A	N/A

VI

CHAMBER MAINTENANCE

Insure trouble-free service by performing preventive maintenance when appropriate. Should service be required, specific procedures are described to locate and repair malfunctions.

TEST EQUIPMENT REQUIRED

The following equipment, or equivalent, is needed to perform maintenance and calibration operations on temperature test chambers.

Temperature calibrator (minimum adjustment 0.1°C or less).

Multitester, 100k ohms/volt, or VOM.

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*                                CAUTION                                    *
*                                                                           *
*    Always disconnect the AC power to the test chamber before              *
*    performing preventive maintenance.                                     *
*                                                                           *
*    Maintenance should be performed by qualified personnel only.           *
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PREVENTIVE MAINTENANCE

The temperature test chamber should be inspected for conditions that might damage it or shorten its service life and should be cleaned at frequent intervals.

Temperature test chamber inspection consists of the following checks:

1. Inspect the coolant cylinder valves to be sure they are properly closed.

2. Inspect the inside of the test chamber for moisture. If moisture is found, operate the test chamber for one hour at 205°C (400°F) to evaporate the moisture.

3. Check coolant lines for proper connections.

4. Check the test chamber motor(s) at elevated temperatures for quiet operation. (This insures proper bearing condition.)

Clean the control unit compartment as follows: (See Figure 11)

1. Disconnect AC input power.

2. Remove vent screen from control unit compartment.

3. Remove dust and foreign particles from components of the control unit compartment with a soft brush and vacuum cleaner, if available.

4. Reinstall vent screen on control unit compartment.

5. Reconnect AC input power.

The CO_2 filter should be cleaned every 30 days or 240 hours of operation, whichever occurs first. Clean the CO_2 filter as follows:

1. To remove the filter, unscrew the hollow Allenhead screw (item 7 in Figure 3) from the test chamber bulkhead fitting (item 5) and slide the filter (item 6) out from the fitting.

2. Wash filter in trichloroethylene.

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*                              CAUTION                                    *
*                                                                         *
*    Use trichloroethylene only in a well ventilated area.  Avoid        *
*    inhaling fumes and excessive contact with the skin.                  *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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3. Dry filter thoroughly with filtered, dry, compressed air at low pressure.

4. Reinstall filter in CO_2 bulkhead fitting.

The coolant solenoid orifice assembly should be cleaned only when necessary. Frequent cleaning should not be required if contaminant-free CO_2 is always used. Clean the coolant orifice as follows:

1. Disconnect AC power. Disconnect coolant hose.

2. Remove vent screen from control unit compartment.

3. Open heater compartment.

4. Remove coolant solenoid assembly from control unit compartment.

5. Remove orifice tube from solenoid assembly. Check position of orifice for reinstallation.

6. Carefully clean orifice using 0.46mm (0.18 inch) diameter music wire.

7. Replace orifice tube in solenoid assembly, performing the removal procedure in reverse order.

8. Reinstall coolant solenoid assembly in control unit compartment.

9. Close control unit and heater compartment.

10. Connect coolant hose.

11. Turn on coolant cylinder valve and check for leaks.

12. Connect AC power.

13. Operate test chamber at low temperature set-point to insure correct cooling function.

CORRECTIVE MAINTENANCE

The purpose of corrective maintenance is to locate test chamber malfunctions and to apply proper repair procedures. Trouble-shooting information to permit isolating test chamber malfunctions and pinpointing their probable causes is given in Table I.

The following procedure is used in trouble-shooting the test chamber:

1. Insure that all switches are in the proper position.

2. Check first for blown fuses and proper AC power connection.

3. Check coolant lines for proper plumbing. Check that all line valves are open. Make sure that the coolant lines are not clogged.

4. Check the coolant cylinders to be sure that they contain an adequate coolant gas supply.

Components in the temperature test chamber are removed and replaced as follows: Repair is limited to the replacement of defective parts.

Remove the heater assembly as follows: (see Figures 12 and 13)

1. Disconnect AC power.

2. Remove screws holding plenum plate.

3. Carefully allow plenum plate to drop downward.

   Caution: Care should be taken not to damage or disturb the location of the thermcouples.

4. Remove two Phillips-head screws at the back of the heater assembly.

5. Remove the two wires connected to the heater coil.

6. Carefully remove heater from chamber.

7. To replace heater assembly, perform the removal procedure in reverse order.

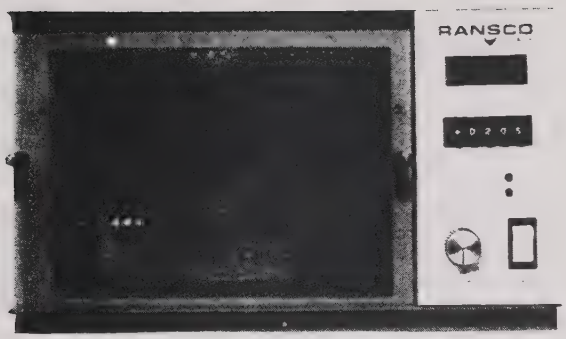

Figure 12. Plenum Plate Before Removal

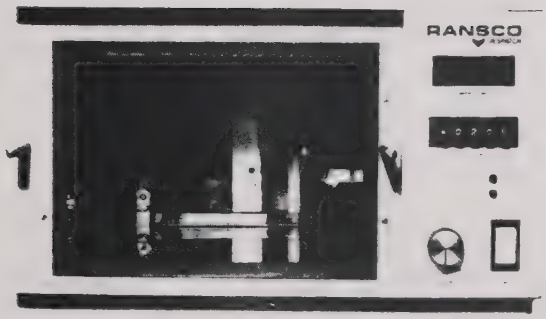

Figure 13. Plenum Plate Removed

TROUBLE	PROBABLE CAUSE
Failure of power indicator light to operate when power is switched on.	Power cord not plugged into outlet. Outlet not powered. Defective line fuse (F1). Defective POWER switch (S1). Defective power cord.
Blowing line fuse when power switch is turned on.	Defective (grounded or shorted) heater (HTR-1). Defective motor(s) (shorted). Defective solenoid valve (shorted) (L1). Short in filter, transformer or control. Shorted wiring, or loose connection touching chassis.
Failure of controller display to light when power light is on.	Loose wiring. Faulty transformer. Faulty readout. Faulty controller.
Chamber temperature differs from set-point indication.	Defective sensor (1 or both). Control out of calibration. Defective control.
Lack of operation of appropriate heat or cool light when control setpoint differs from display by more than 0.3°C.	Faulty light. Defective controller.

CHAMBER TROUBLESHOOTING

TROUBLE	PROBABLE CAUSE
Failure to control at a low temperature when cool light is on.	Cylinder valve not open.
	Lack of liquid coolant.
	Clogged CO_2 filter.
	Clogged orifice.
	Clogged line.
	Solenoid valve will not open.
Failure of chamber to heat when heat light is on.	Faulty heater fuse (F2).
	High limit (Dial) set below chamber temperature.
	Defective solid-state relay (SSR1).
	Defective contactors (K1 or K2).
	Defective heater (HTR-1).
	Defective heater cable.
	Solenoid valve will not close.
	Defective control.
Failure of solenoid valve to close when cool light is on.	Ice in valve.
	Defective valve.
	Defective solid state relay.
	Defective control.
Failure of solenoid valve to open when cool light is on.	Defective valve. Defective solid state relay.
	Defective control.

CHAMBER TROUBLESHOOTING (CONT'D)

SERVICE PROCEDURES

Remove the main blower motor as follows: (see Figure 14)

1. Disconnect AC power.

2. Remove screws holding plenum plate.

3. Carefully allow plenum plate to drop downward.

   Caution: Do not damage thermocouples or disturb placement.

4. Loosen Allen set screw holding blower motor fan blade or blower wheel to motor shaft.

5. Remove fan blade or blower wheel. In some cases, a gear puller will be needed for removal of the fan from the motor shaft.

6. Remove vent screws from control unit compartment.

7. Remove blower motor wires from terminal strip.

8. Remove three Phillips-head screws connecting the blower motor to this mounting platform.

9. On models 934 and 936, remove motor shaft pin.

10. Remove blower motor.

11. To replace blower motor, perform the removal procedure in reverse order.

Remove the electronic control chassis as follows:

1. Disconnect AC power.

2. Remove vent screen from motor compartment.

3. Remove holding screw located above rear of RDC control within motor compartment. (On Models 934, 924, 936, and 926.)

4. Remove two holding screws on rear of chamber above fuses.

5. Remove holding screws (two on Models 934, 924, 936 and 926 on exterior bottom of chamber; three holding screws through chassis on Models 925 and 936).

6. Remove wires connected to terminal strip.

7. Remove control chassis by sliding it towards the front of the chamber.

8. To replace the control chassis, perform the removal procedure in reverse order.

ADJUSTMENT AND TESTING OF THE FACTORY CALIBRATED HIGH LIMIT THERMOSWITCH

1. The thermoswitch was factory set and tested at the chamber maximum rated temperature within normal tolerance.

2. If necessary to reset the thermoswitch, it is accessible by removing the snap in closure button in the rear cover panel.

3. A screwdriver can be inserted through the hole to find the end of the slotted adjusting screw.

4. Turn screw clockwise to reduce temperature. Adjusting rate is approximately 90°F per revolution.

5. To set a new temperature on the thermoswitch, set the chamber control to the desired trip temperature and allow temperature to stabilize. The panel mounted overtemperature setpoint must be set at a higher temperature for this test. Slowly turn adjusting screw clockwise until the thermoswitch trips and the chamber is shut down.

6. Test the setpoint by allowing the chamber to cool, open and close the power switch to reset, set the chamber controller above the set point and observe the temperature at the time it is tripped.

7. Reset the electronic overtemperature set point to the desired temperature.

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